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Land management for increased flood resilience

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Land management for increased flood resilience



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Contents

EXECUTIVE SUMMARY	1
1.0 INTRODUCTION	2
2.0 FARMERS' ATTITUDES TO NATURAL FLOOD MANAGEMENT MEASURES	2
3.0 POTENTIAL IMPACTS OF NATURAL FLOOD MANAGEMENT MEASURES ON FARM INCOME	8
4.0 ASSESSING ACCEPTABILITY OF POTENTIAL COMPENSATION LEVELS FOR IMPLEMENTING NATURAL FLOOD MANAGEMENT MEASURES	13
5.0 DISCUSSION: INFORMING THE DESIGN OF MECHANISMS TO TARGET IMPLEMENTATION OF NATURAL FLOOD MANAGEMENT MEASURES	21
6.0 REFERENCES	25
7.0 ABBREVIATIONS AND GLOSSARY	26

Executive Summary

Key findings

Farmers' attitudes to NFM measures:

- Planting trees alongside a watercourse is the most favoured measure.
- NFM measures that involve a reduction in yield or useable land area are not favoured.
- Farmers have significant concerns over potential loss of capital and annual values due to loss of workable land and, on the loss of control over how land may be used in the future.
- Financial incentives are more favoured than non-financial incentives. Annual payments are more attractive than one off payments. Full cost grants are preferred over partial grants.
- Farmers require evidence of the effectiveness of measures before committing to a scheme.
- Farmers showed a preference for receiving information about NFM measures and schemes face-to-face on the farm, but there was no clear indication of a preference for a single source of information, rather Scottish Government, SEPA, NFU Scotland and farm advisers were all seen as important.

Potential impacts of NFM measures on farm income:

- The impact of different NFM measures varies according to the type of measure and its precise location within the farm system, due to the complex financial interplay between these variables and their overall impact on farm business income.
- Financial impacts include loss of agricultural income; loss of agricultural subsidies; retention of other fixed costs and additional management costs, offset by reductions in variable costs and some fixed costs.
- Impact on subsidy income can be assessed through consideration of impacts of NFM measures on the main agricultural support schemes. Loss of income, and therefore level of income foregone is highest on the best performing land, such that costs of compensation will be greatly reduced by targeting poorer land and unproductive farms.
- The important role that subsidy payments have in pushing up the cost of compensation are clearly shown, since removing land from eligibility for subsidy payment results in a marked rise in compensation required. The relative effect is much greater on poor hill land where subsidies make up a higher proportion of farm income.
- In all cases where an NFM measure was proposed, the compensation levels offered produced at least a neutral and, in most cases a positive response from respondents. In most cases, and in line with economic theory, increasing the level of compensation led to an increase in the likelihood of that measure being seen as acceptable for that land use type.

Policy instruments to support NFM in Scotland:

- The use of tax-based incentives to encourage uptake of NFM measures received a mixed response. There was limited support for auction schemes and service trading options.
- Very little support is shown for outright purchase of land or lease back arrangements due to loss of control over land.

- The policy context offers two potential approaches for encouraging NFM via economic incentives. The Flood Risk Management (Scotland) Act 2009 allows for agreements to be established between local authorities and land managers, which could be one route to promote widespread uptake of NFM measures. Secondly, it may be possible to utilise the Scottish Rural Development Programme to make it better able to accommodate NFM.
- In both instances, prioritising spend on NFM measures in relevant areas and encouraging landowners to cooperate in bringing forward joint applications at a catchment scale should be supported.

Targeting NFM measures on Scottish farms:

- Certain NFM measures are more attractive to farmers than others.
- The measures generally most favoured are woodland planting alongside watercourses, in hill and in-bye areas, and the fencing off of water courses.
- NFM measures deliver for flood risk reduction at different scales and those that are not seen as favourable by farmers, such as the large-scale creation of areas of sacrificial flood land in arable areas may still be very relevant in certain circumstances, such as immediately upstream of vulnerable communities; their introduction requiring other incentives and means through which they can be delivered.
- A catchment approach must be taken to the planning, approval, design and implementation of NFM measures.

Background

Natural Flood Management (NFM) is fundamental to achieving the aims of the Flood Risk Management (Scotland) Act 2009 and to deliver sustainable flood management strategies. However, little is known of its potential financial impact and economic acceptability to the farming and land management community. To support policy development and implementation, empirical data on the business impacts of proposed NFM measures is needed, including information on the willingness of farmers to introduce different types of NFM measures within different farming systems.

Research undertaken

The main objectives of the research were to undertake:

1. a large-scale survey of farmers' attitudes to NFM and to the use of potential policy instruments to promote its uptake and delivery;
2. an economic analysis of the impact of different NFM measures under different scenarios and across different farming systems.

Key words

Natural flood management; Farm income; Sustainable agriculture; Land management; Flood policies; Integrated Water Resource Management; Catchment-based approach.

1.0 Introduction

Natural Flood Management (NFM) (e.g. restoring watercourses, riparian tree planting, washland and wetland creation) is a core component of flood risk management strategies in Scotland. However little is known of its potential impact on the farming and land management communities, individual farm businesses, or the socioeconomic impacts and perceptions of its potential wide-spread introduction. To support policy implementation, information is required on land managers' willingness to implement NFM, and to be able to relate willingness to generic farm characteristics (farming systems, land use types, geographical location), different types and locations of NFM measures, and to farm economics.

The main objectives of the project are to undertake:

1. A large scale survey of farmers' attitudes to NFM and to the use of potential policy instruments to promote its uptake and delivery; and
2. Farm-scale economic analyses of the impact of NFM measures under different scenarios.

The project takes a whole catchment approach, utilising the River Tweed catchment as representative of the range of landscapes, farming types and flood issues to be found across Scotland. In total, the Tweed basin covers some 5,000 sq. km from source (840m) to sea, 84% of which lies in Scotland. The project builds on the results of work undertaken by Smiths Gore for the Scottish Government on *Land owner compensation and approaches for flood protection work* (Beedell *et al* 2012), and complements the SEPA Natural Flood Management Handbook.

1.1 Survey of farmers' attitudes

The specific objectives identified for the first part of the work were to:

- prepare a questionnaire to cover the views of farmers on NFM and policy measures;
- widely disseminate the questionnaire through a dedicated website/on-line survey using farmer and land manager networks; and
- undertake statistical analysis to identify willingness, generic farm and land-holding characteristics, and types and extents of NFM measures and policy options.

1.2 Farm-scale economic analyses

Building on these results, the project then looks at the potential financial implications to farmers if flood risk to specific parts of the farm was deliberately altered through the introduction of different NFM measures. In doing so, it aimed to:

- identify and build individual farm financial business models that could be used to explore different flood risk scenarios;
- identify the key costs and impacts of increased flood risk, and relate these to potential incentive mechanisms to change land use (as derived from the Smiths Gore report);
- examine these in relation to SRDP mechanisms; and

- investigate farmers' willingness to change their behaviour and adopt NFM measures.

In bringing these two elements together, the work attempts to assist planning and implementation of the Flood Risk Management (Scotland) Act 2009 and, more specifically, the identification of the types and locations of farming systems most appropriate for the introduction of NFM measures as part of a balanced approach to sustainable flood risk management. It looks to inform the development of proposals for linking NFM implementation with the Scottish Rural Development Programme (SRDP), and provide new information on the financial and incentive arrangements most likely to achieve farmer uptake of specific measures in desired locations. The key audiences for the work are seen as being the statutory authorities with responsibilities for flood risk management, farmers, and land management and catchment organisations working on the ground.

1.3 Methodology

The study design reflects the objectives (above). The work is divided in to three distinct parts.

1. A survey exploring attitudes of farmers to NFM measures, and the feasibility of their implementation via existing policy instruments.
2. A desk study of actual farm incomes in the Scottish Borders under different land management options.
3. Involving the farmers who had participated in the initial detailed survey and, using estimates of Agricultural Income Foregone derived from part 2 asked them to 'sense-check' both the methodology and the results in respect of the different NFM measures and farm land types. This enabled us to assess their willingness to consider uptake of different NFM measures on specific land use types when offered a range of levels of financial incentive.

Further information on the methodology for each part is provided in the individual sections of the report.

2.0 Farmers' attitudes to natural flood management measures

As noted, the primary aim of part 1 was to undertake a survey to explore the attitudes of farmers to NFM measures and their implementation via existing policy instruments. The survey was structured around six key components: – respondent details; land characteristics; NFM measures; challenges to NFM adoption; the policy landscape; and incentives.

2.1 Detailed methodology

The survey was undertaken using Lime Survey, an open source survey application and, prior to its launch, a pilot survey was undertaken with ten local farmers to assess the usability of the survey tool and to determine whether the questions were appropriate.

The survey was disseminated across the Tweed catchment via a series of Borders' networks: Tweed Forum; Scottish Borders Council (Flood group); National Farmers Union Scotland; and Scottish Land and Estates, using either email or postal methods. Due to low uptake, this was extended to include the Borders' office of SRUC, the NFU in the lower Tweed, and Smiths Gore who contacted farmers they had worked with from the earlier study. Finally, we undertook three brief early morning broadcasts on Radio Borders' highly popular Farming programme.

2.2 Coverage and Response demographics

Forty six respondents returned their surveys which took up to 30 minutes to complete in full. Farms were split into three land types:

- Hills - 23 responses;
- In-bye land - 32 responses; and
- Land prone to flooding - 30 responses.

Several of the respondents had land in more than one category and many had experienced flooding – 9 of the 23 in the hills, 14 of the 32 with in-bye land and 27 of the 30 with land prone to flooding had noted instances in the last ten years.

Together, the returns represented the full range of farming options covered by the questionnaire: 36 respondents owned farmland, 13 were tenant farmers and three were contract farmers (some indicated their farming fell into more than one category). Some respondents indicated that their land had been farmed in their family for over 100 years, with other responses ranging from less than five to more than 35 years. Male respondents dominated and their age range was unevenly split, with considerably more in the 56 to 65 year category than any other.

2.3 Which types of NFM measures would be considered?

Respondents were asked which of 11 potential NFM measures (ponds and temporary water storage, tillage practices, buffer and grass strips, arable to grassland conversion, removing watercourse levees and embankments, re-meandering straightened watercourses, upland grip and drainage ditch blocking) they would consider implementing on their land, giving a score for each measure from: 1 – Would not consider, through to 5 - Would definitely consider. A summary of the responses to each measure is shown in Table 1.

The NFM measure most likely to be considered favourably was planting trees along a watercourse, although there was still a mix of opinion, with a number indicating they would be unlikely to consider it. Buffer strips and grass strips were also popular with some respondents, which may reflect a similar response to waterside tree planting, whilst creating ponds and temporary water storage structures also attracted some support.

Overall the responses suggest a reluctance to consider measures that would reduce yield or significantly reduce the area of useable land available. In this respect, the NFM measure least likely to be considered by farmers is blocking tile drains, with planting large areas of trees, reducing stock density and removing river embankments and levees also not favoured.

Many of the measures considered in the survey gave a mixed response, with a more even split between the respondents indicating a willingness to consider the measure and those who would not consider it. This would seem to suggest that even some of those measures that are generally unpopular might be looked on more favourably by individuals in certain, specific circumstances. In this respect, it is interesting to note that re-meandering rivers, for example had some supporters.

It was initially considered that farm size could play a part in influencing the acceptability of certain types of NFM, particularly on smaller holdings where a measure might occupy a relatively large area of ground. An analysis of the returns (Figure 1) demonstrates no correlation between farm size, or turnover and the likelihood to accept a measure.

Table 1: How likely are you to consider implementing this NFM measure?

Measure	Number of responses (% of responses) (1 – Would not consider, through to 5 - Would definitely consider). Median value in bold						Mode
	1	2	3	4	5	No answer	
Reducing stock density	23 (50%)	4 (9%)	6 (13%)	1 (2%)	3 (7%)	9 (20%)	1
Converting arable land to permanent grassland	14 (30%)	5 (11%)	8 (17%)	1 (2%)	2 (4%)	16 (35%)	1
Adopting certain tillage practices	8 (17%)	5 (11%)	10 (22%)	7 (15%)	4 (9%)	12 (26%)	3
Re-meandering rivers	15 (33%)	5 (11%)	6 (13%)	5 (11%)	6 (13%)	9 (20%)	1
Buffer strips and grass strips	8 (17%)	4 (9%)	5 (11%)	7 (15%)	10 (22%)	12 (27%)	5
Creating ponds and temporary water storage structures	7 (15%)	2 (4%)	12 (26%)	9 (20%)	12 (26%)	4 (9%)	3 & 5
Removing river embankments and levees	22 (48%)	5 (11%)	6 (13%)	0 (0%)	2 (4%)	11 (24%)	1
Planting large areas of trees	17 (37%)	13 (28%)	5 (11%)	2 (4%)	3 (7%)	6 (13%)	1
Planting trees along a watercourse	7 (15%)	5 (11%)	6 (13%)	10 (22%)	14 (30%)	4 (9%)	5
Grip blocking or drainage ditch blocking	16 (35%)	5 (11%)	8 (17%)	2 (4%)	3 (7%)	12 (27%)	1

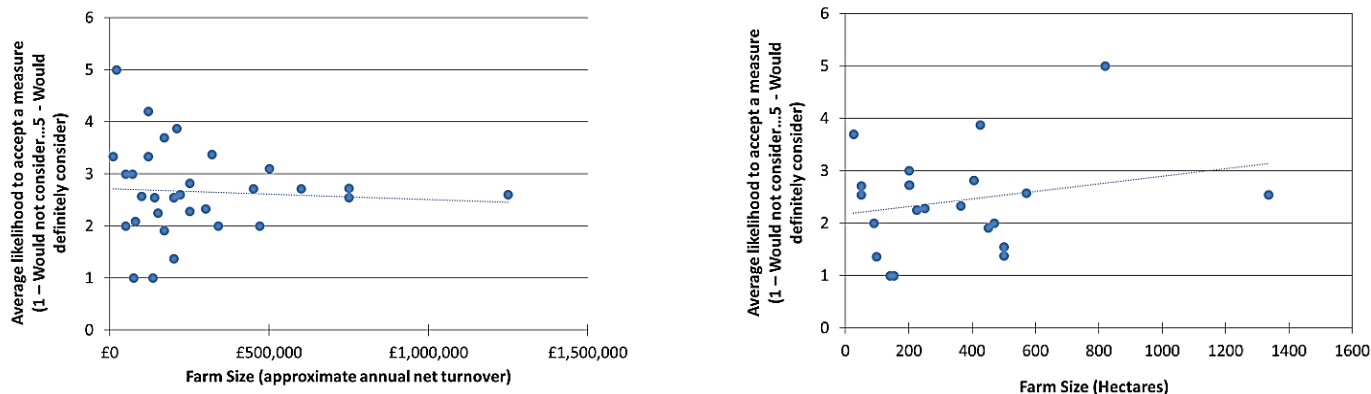


Figure 1 Exploration of the correlation between (a) farm size (turnover) and (b) farm size (hectares) and the likelihood to accept a NFM measure

2.4 What are the main concerns about adopting NFM measures?

In order to explore the reasons behind potential opposition to implementing NFM measures, respondents were asked how concerned they are about a number of issues when considering implementing different groups of measures. The survey covered 15 potential issues and, for the purposes of the survey, NFM measures were grouped into three categories and respondents were asked for their views about the group of measures rather than an individual measure:

1. Measures that reduce the amount of land available to farm – including: arable to grassland conversion, buffer strips, grass strips, ponds and permanent water storage, re-meandering the watercourse, planting trees.
2. Measures that need a change in the way that land is farmed – including: arable to grassland conversion, reducing stock densities, tillage practices.
3. Measures that make no permanent change to the land available to farm but have an increased risk of temporary land loss due to flooding or saturation – including: removing levees and embankments, grip blocking, drainage ditch blocking, tile drain blocking.

The three main concerns raised for each of the groups of measures were:

- the loss of annual value due to loss of workable land;
- the loss of capital value due to loss of workable land; and
- issues around the potential for changing the use of land put into NFM measures in the future.

Table 2 shows the results and demonstrates that the trends were similar for all three groups of NFM measures, although the numbers indicating they were 'very concerned' about annual and capital value loss were slightly lower for groups 2 and 3 than for group 1.

There were strong concerns about on-going maintenance costs for the group of measures that reduce the amount of land available to farm (group 1), and concerns about the increased risk of flooding for the measures that make no permanent change to the land available to farm but have an increased risk of temporary land loss due to flooding or saturation (group 3).

Table 2: How concerned are you about these issues when considering implementing different groups of NFM measures? (1. Measures that reduce the amount of land available to farm; 2. Measures that need a change in the way that land is farmed; 3. Measures that make no permanent change to the land available to farm but have an increased risk of temporary land loss due to flooding or saturation). 1 - Not concerned ... 5 - Very concerned

Issue	Group of measures	Responses	Median	Mode
Loss of capital value due to loss of workable land	1	45	5	5
	2	41	5	5
	3	40	5	5
Loss of annual value due to loss of workable land	1	46	5	5
	2	42	5	5
	3	40	5	5
Loss of option to change use of land in future	1	45	5	5
	2	40	5	5
	3	39	5	5
Ongoing maintenance costs	1	45	4	5
	2	41	4	5
	3	38	5	5
Increased risk of flooding on land	1	43	4	5
	2	41	4	5
	3	39	4	5
Lack of information prior to implementation	1	42	4	5
	2	39	4	5
	3	36	4	5
Lack of support once implemented	1	42	4	5
	2	40	4	5
	3	36	4	5
Initial cost of implementation	1	44	4	5
	2	42	4	5
	3	38	4	5
Liability if flooding occurs downstream	1	43	4	5
	2	37	4	5
	3	35	4	5
Problems with pests and parasites	1	35	5	3
	2	41	4	5
	3	37	4	5
Weed encroachment	1	43	4	3
	2	37	3	5
	3	34	3	5
Issues with neighbouring farms	1	43	3	3
	2	40	3	2
	3	36	3	5
Employee health and safety	1	42	3	3
	2	38	3	5
	3	36	3	3
Public Health and safety	1	43	3	1
	2	39	3	5
	3	37	3	5
Visual impact	1	33	2	3
	2	40	3	3
	3	36	4	4

2.5 What would be considered as an incentive to adopt NFM measures?

A range of incentives, such as financial, policy or environmental gains, could encourage the deployment of NFM measures, alongside consideration of different instruments to achieve uptake including, for example, land purchase (with or without lease back) and capital grants. To understand which might be acceptable to farmers, participants were asked about a range of incentives. For the purposes of the survey these were grouped into three categories:

1. Incentives for initial creation and installation of NFM measures;
2. Incentives for implementing and maintaining NFM measures;
3. Other incentives.

2.5.1 Incentives for initial creation and installation of NFM measures

Participants were asked for their preference (from 1 - would not consider, to 5 - would definitely consider) for incentives for initial creation and installation of NFM measures. The four possible scenarios presented to them were:

- Full-cost grants to contribute towards any initial set-up costs;
- Partial grants to contribute towards any initial set-up costs;
- Selling an area of land and transferring ownership; and
- Selling land and managing through lease or licence.

Participants strongly favoured full cost grants to cover initial set up costs with all respondents who answered the question indicating they would consider the option an incentive and 37 out of 42 giving it the highest mark (5) of 'would definitely consider'. In addition to full-costs grants, partial grants were also attractive. There was a strong indication that for many farmers, options for selling areas of land would not be considered an incentive, and this applied to both the option of selling land and transferring ownership, and selling land and managing through a lease back or license arrangement. However, it should be noted that a small minority found both sale options highly attractive, probably reflecting individual circumstances at that time.

2.5.2 Incentives for ongoing maintenance and implementation of NFM measures

Participants were presented with six potential scenarios as incentives for ongoing maintenance:

- a one off payment to cover income lost;
- annual payments to cover income lost;
- a one off payment to cover future increased flood risk;
- annual payments to cover future increased flood risk;
- selling land and leasing to a trust; or
- selling land and managing through a lease.

As with initial set up costs, there was a strong indication that the last two options that included selling areas of land would not be considered an incentive.

When considering incentives for implementing and maintaining measures, there was a much greater preference for annual payments than one off payments to cover income lost. Thirty five out of 45 respondents who answered the question selected option 5 (would definitely consider) annual payments and only one chose option 1 (would definitely not consider). When presented with a one-off payment scenario only seven chose option 5 (would definitely consider) against 20 who expressed option 1 (would definitely not consider). This preference for annual rather than one off payments was also evident in the response to the option of receiving payments to compensate for increased future flood risk where 29 out of 44 respondents selected option 5 (would definitely consider) when asked about an annual payment, but 29 out of 44 respondents selected options 1 or 2 (would not consider) when asked about one off payments.

2.5.3 Other Potential Incentives for adoption of NFM measures

There was a mixed response to questions about other forms of incentives, including non-financial incentives with more responses falling in the mid-range of answers. Participants were presented with eleven other incentives grouped around eight broad themes:

- Tax-based incentives (no capital gains tax; or no inheritance tax on land set aside for NFM);
- Payments to cover increased insurance against flooding;
- Payments for enhancing the environment (one-off; or annual);
- Favourable weighting for environmental grants;
- Auction schemes; or Service Trading schemes;
- Recognition through award of an Environmental Mark;
- Reducing flooding downstream; and
- Provision of ecological stability.

The response to questions about tax based incentives (no capital gains tax or no inheritance tax on land set aside for NFM measures) was rather polarised, with just over half indicating a very favourable response (22/40 scoring options 4 or 5 for both taxes), but 15 (for tax inheritance) and 13 (for capital gains tax) scored only options 1 or 2.

Interest was also expressed in annual payments for enhancing the environment (28 out of 43 selected would definitely consider), while only 5 said they would definitely consider a one off payment for enhancing the environment.

While not considered as good an incentive as annual payments, results also suggest that receiving a favourable weighting for environmental grants was considered a good incentive with 19 out of 34 respondents saying they would definitely consider it (option 5).

The results for auction schemes and service trading options indicate that at present they might not be considered so favourably, with 'option 1 -would not consider' selected by 22 out of 39 for auction schemes and 19 for service trading. However, there was a spread of responses to these questions with a few respondents indicating they would definitely consider. This may reflect uncertainty around the novelty and operation of such schemes.

2.6 What information is required and how should it be presented?

In itself, the information on farmers' views on current NFM measures and the range of incentives that would be considered is useful. Another factor however, in encouraging a behavioural change towards adoption of NFM measures is to understand what information participants felt they needed, and from whom this should be available, before they were able to make informed judgements about introducing NFM measures on their land.

To explore this issue, we asked respondents about the evidence they would require and from whom they expected to receive guidance and support. Forty out of 46 respondents indicated that evidence of the effectiveness of NFM measures was considered essential (scoring 5) before participating in any schemes. Knowing who to contact if there were problems with the measure once it was in place was also considered important (42 scored 4 or 5), while seeing a particular NFM measure in action received a slightly more mixed response but still 34 out of 45 respondents selected options 4 or 5.

Preferences were expressed for receiving information about NFM measures and schemes face-to-face on the farm, rather than at local meetings. Having access to information online was also favoured, but there was also a place for written action sheets to be made available. Perhaps surprisingly, there was no clear indication of a preference for a single source of information, rather Scottish Government, SEPA, NFU Scotland and farm advisers were all seen as important.

Most respondents thought that the Scottish Government should support/promote the scheme (30), but a considerable number also indicated SEPA (18), NFU Scotland/Scottish Land & Estates (16), local authorities (15), and non-governmental land management organisations (12) should have a role in support and promotion.

2.7 Joint applications

A final question approached the subject of how planning and implementing NFM measures could be geographically 'joined-up' at a catchment scale to reduce flood risk, rather than being physically isolated initiatives on selected participating farms. One way proposed was to promote support for joint initiatives from neighbouring land owners and farmers. There was generally a positive response to the question asking whether respondents would consider submitting joint applications with neighbouring farms, though a certain amount of caution was implied. Twenty nine of the 43 who responded indicated that they would consider or definitely consider joint applications (scores 4 or 5), with five indicating they would not or definitely not consider this.

2.8 Farmers' attitudes to Natural Flood Management Measures – Summary

Whilst a number of questions produced mixed responses, with answers covering the whole range of options, it is clear that certain distinct trends emerge from the data gathered from the 46 detailed returns. The difficulty in answering general questions regarding NFM measures without having information about

how they might specifically apply to an individual farm was noted in comments in the survey and is explored later with the financial modelling. It no doubt also reflects the 'personal' nature of individual responses, with views depending on individual farm and location characteristics.

Key messages that help inform policy development include:

- Adopting NFM measures that reduce yield or useable land area are not favoured
- The NFM measure most likely to be considered by all is planting trees along a watercourse
- For other NFM measures, there is a more even split between respondents indicating a willingness to consider the measure and those who would not consider it, such that even options such as sale of land might be attractive in individual circumstances
- There are concerns over potential loss of capital and annual values due to loss of workable land
- The loss of control over how land may be used in the future is a noticeable concern
- Financial incentives are more favoured than non-financial incentives
- Annual payments are considered more favourable than one off payments
- Full cost grants are considered a key incentive although partial grants may also be considered
- Having evidence of the effectiveness of measures before committing to a scheme was considered very important as, to a slightly lesser extent, was seeing it in action
- Face-to-face communication on the farm was favoured, along with knowing who to contact if there were problems with NFM measures
- There is no preference for a single source of information, rather Scottish Government, SEPA, NFU Scotland and Farm Advisers were all seen as important
- Scottish Government should support/promote NFM, but SEPA, NFU(S)/SLE, local authorities and NGO land management organisations should also have a role.

3.0 Potential impacts of natural flood management measures on farm income

This next section, Part 2 of the work examines the impact of what were seen as the most feasible and acceptable NFM measures for specific locations on typical farm businesses. It aligns these with the main NFM measures described in the SEPA Natural Flood Management Handbook. This introduced an element of inconsistency in terminology, as the exact grouping and definitions for different measures used in the SEPA NFM Handbook were not available at the start of this project. However, this does not affect the main analyses and conclusions, but we would caution that the naming of measures and use of language could have a degree of influence over how measures are perceived.

The specific objective here was to provide robust estimates of agricultural income that would be foregone on typical land classes in the south of Scotland if impacted by different NFM measures.

3.1 Detailed methodology

Full details of the methodology and results are available in the separate report by SAC Consulting. Key aspects are dealt with below.

3.1.1 Land types

In order to represent the range of land types where NFM measures might be introduced across a typical catchment in Scotland, farm income foregone estimates were prepared for four “typical” land types spanning the uplands and lowlands of the south of Scotland. These have then been matched to financial data collected for specific farm types under the Scottish Government Farm Account Scheme (FAS), detailed below:

Land class	FAS farm type
(i) Hill – unimproved grassland	“Specialist sheep (Less Favoured Areas LFA) farms” (FAS)
(ii) In-bye – improved grassland	“Specialist beef (LFA) farms” (FAS)
(iii) Lowland – arable	“Cereals farms” (FAS)
(iv) Lowland – arable high value	“General cropping (non-LFA) farms” (FAS)”

3.1.2 Natural Flood Management measures

The impact of NFM measures on agricultural land use and income will vary according to the type and mode of operation of the measures concerned, and their physical location within the landscape and farming systems. Some NFM measures, such as re-meandering a river will, in effect have the same impact on farm income as simply fencing off the watercourse; the actual difference to the agricultural income foregone being the impact of the size of land area lost to production, as opposed to the nature of the physical re-meander that occurs in the fenced off location. We therefore focussed our detailed financial analysis on the main types of NFM measures that appear acceptable to at least some farmers, as revealed by earlier surveys in

this study and others. We make no assumptions as to their individual effectiveness to reduce flood risk.

We have attempted to match the main types of NFM measure we used in this analysis to the terminology and measures as seen in a draft of the SEPA NFM handbook, in which further details of the exact nature of each measure can be found:

Woodland creation and management

- Woodland creation - native broadleaves
- Agroforestry

Land management

- Land and soil management - reducing stocking density
- Agricultural and upland drainage - blocking drains

Working within and on the banks of the channel

- Bank restoration - removing existing banks
- Fencing off watercourses

Runoff (pathway) management

- Creation of wetlands

3.1.3 Financial data used

The financial data used in this study was sourced from the Scottish Government's Farm Accounts Scheme survey which is the primary source of farm income data for Scotland, covering over 500 farms. This represents the most comprehensive and stratified sample of farm businesses available. This was supported by inclusion of a subset of data from farms located in the south of Scotland (Dumfries and Borders) covering the area of our surveys, as well as cost and income data from the SAC Farm Management Handbook and other suitable sources (see: <http://www.scotland.gov.uk/Topics/Statistics/Browse/Agriculture-Fisheries/Publications/FASmethod/FASmethod2013>).

Financial data from the last three years (2010/11 -2012/13) were used to produce average values, and thus minimise yearly fluctuations in weather or market conditions. Relative performance data were used to calculate income foregone estimates for the lower 25% performing farm businesses, as well as the average. It should be recognised that the fine detail of actual costs and income foregone will vary from place to place including, for example the precise way in which an NFM measure is implemented, and its exact location.

3.1.4 Estimating income foregone and impact on subsidy payments

The estimated net loss of agricultural income to the farm business was calculated for every hectare of land either removed from agricultural production, or where agricultural output was negatively affected by the introduction of NFM measures. The main financial impacts considered were as follows;

Negative

- loss of agricultural income
- loss of agricultural subsidies
- retention of other fixed costs which result in a higher burden for the remaining land in agricultural production
- additional management costs

Positive

- reduction in variable costs (seeds, fertilisers, feeds, fuel etc.)
- reduction in some fixed costs (machinery, etc.).

The impact on subsidy income was assessed through considering the impact of implementing different NFM measures on the main agricultural support schemes applicable in Scotland:

- Single Farm Payment (SFP)
- Scottish Beef Scheme (SBS) (coupled head-age payment)
- Less Favoured Area Support Scheme (LFASS)

These support schemes are funded by the EC Common Agricultural Policy and are subject to conditions defined in the Integrated Administration and Control Systems. In general, where land remains in agricultural production, eligibility for agricultural subsidies continues as long as the conditions of the schemes are met (adherence to Good Agricultural and Environmental Conditions).

Given the timing of this study, mid-way through the implementation of CAP reform, it has not been possible to obtain the final details for several of these support schemes. We therefore used the data available from the previous CAP schemes.

In order to arrive at the figures given, a number of assumptions have to be made and, in particular whether the land remains eligible for direct payments (Single Farm Payment or its successor Basic Payment Scheme). In the following sections and in Table 6, it is assumed that woodland creation is undertaken through SRDP and thus the land remains eligible for direct payments. By comparison, it is assumed that fencing off a watercourse takes land out of production and there is a loss of production and hence also a loss of subsidy.

If agricultural production is reduced but not eliminated, then subsidy could be maintained and compensation could be paid for loss of production – through SRDP or by agreement with a local authority for example. Land managers would need to comply with rules over eligibility of land in order to maintain their agricultural subsidy.

Finally, it should be noted that if land is taken out of production, a local authority or other public body might not be able to compensate for loss of subsidy income.

3.1.5 Scenario assumptions

The impact on the farm's financial performance will vary according to the type of NFM measure and the impact on farm production and subsidy eligibility.

Changes in production have been set as follows: remaining in agriculture but reducing production by 25%, 50% and 100%; moving from crops to grass (arable farms only); and removing the land from agricultural production altogether. Where land has been switched from crops to grass, output and variable cost figures have been taken from the FAS "Lowland cattle and sheep" farm type whilst subsidy and fixed costs remain unchanged from the rest of the arable farm.

The assumptions used in the analysis are detailed in the following table 3:

Table 3: NFM measures financial impact assumptions		
	Agricultural production – reduced	Agricultural production - ceased
Agricultural income	Reduction of 25-100%	Nil agricultural income
Agricultural subsidy	Single Payment – unchanged LFASS – unchanged Special Beef Calf Scheme – reduced pro rata with the drop in production	Nil agricultural subsidy
Variable costs	Reduced pro rata with drop in production	Reduced to nil
Fixed costs	Labour costs – unchanged Machinery – reduced pro rata at 50% of the level of production decline Other – unchanged	Labour costs - unchanged Machinery costs - 50% reduction to reflect lower maintenance, fuel Other – unchanged

3.1.6 Income foregone calculations

The calculations used to estimate net income foregone (per hectare) were as follows:

Net Income foregone = the difference in Farm Business Income (FBI) between existing agricultural activity and reduced or ceased activity under the NFM measures.

In turn Farm Business Income was calculated as follows:

Farm Business Income (excluding subsidies) = Agricultural output LESS variable costs LESS fixed costs

Farm Business Income (including subsidies) = Agricultural output LESS variable costs LESS fixed costs PLUS subsidies

Note that within the FAS scheme, all income and costs relating to diversification and farm income are excluded from the farm financial figures, except for agricultural contracting.

3.2 Results

3.2.1 Income Foregone – by land class

Farm Business Income is an estimate of the annual 'profit' from farming activity and will be affected by any NFM measure that affects the level of agricultural production, eligibility for subsidy and costs. Estimates for the impact on different farm types and performance levels are as follows:

Farm Business Income (including subsidies) for average performing farms

Changes in production relating to NFM measures had the following effect on FBI:

Hill – unimproved – FBI £59/ha - reduction of between £12/ha and £144/ha

In-bye – improved – FBI £54/ha - reduction of between £19/ha and £210/ha

Lowland – arable – FBI £183/ha - reduction of between £116/ha and £734/ha

Lowland – arable high value – FBI £330/ha reduction of between £158/ha and £878/ha

Farm Business Income (including subsidies) for lower 25% performing farms

Changes in production relating to NFM measures had the following effect on FBI:

Hill – unimproved – FBI -£11/ha – reduction (increase) of between (£3/ha) and £102/ha

In-bye – improved – FBI -£5/ha - reduction of between - £6/ha and £117/ha

Lowland – arable – FBI -£82/ha - reduction of between £77/ha and £574/ha

Lowland – arable high value – FBI £71/ha - reduction of between £75/ha and £558/ha

Once Farm Business Income has been determined, annual Income Foregone has then been calculated simply as the difference between FBI before and after production changes as a result of NFM measures. Results for average and lower 25% performing farms are shown in table 4.

As expected, the results demonstrate that the loss of income and therefore the level of Income Foregone will be highest on the best performing land. Therefore the cost of compensation will be much reduced by targeting NFM measures on poorer land and less productive farms.

The important role that subsidy payments have in pushing up the cost of compensation is clearly shown. Removing land from eligibility for agricultural subsidies results in a marked rise in the compensation required. The relative effect is much greater on poorer hill land where subsidy makes up a greater proportion of farm income.

Table 4: Annual Net income foregone on average and lower 25% performing farms (AG is Agricultural production)

						£ per ha
Average farm performance	AG. Un-changed	AG. DOWN 25%	AG. DOWN 50%	AG. DOWN 100%	CROPS to GRASS	OUT of AG.
NET INCOME FOREGONE						
1) Hill - unimproved grassland	-	12	24	69	-	144
2) Inbye - improved grassland	-	19	38	104	-	210
3) Lowland - arable	-	116	233	466	326	734
4) Lowland - arable high value	-	158	315	632	474	878
						£ per ha
Lower 25% farm performance	AG. Un-changed	AG. DOWN 25%	AG. DOWN 50%	AG. DOWN 100%	CROPS to GRASS	OUT of AG.
NET INCOME FOREGONE						
1) Hill - unimproved grassland	-	-2	-3	18	-	102
2) Inbye - improved grassland	-	6	12	37	-	117
3) Lowland - arable	-	77	154	231	296	574
4) Lowland - arable high value	-	75	149	225	393	558

3.2.2 Income Foregone – by NFM measure

The following tables detail the categories of NFM, the assumed annual impact on agricultural and subsidy income and calculated Income Foregone by land class for average and lower 25% performing farms.

Table 5 – Annual Net income foregone for different types of NFM measure on average and lower 25% performing farms								
AVERAGE farm performance	Assumed fall in ag. output	Eligibility for subsidy			Net Income Foregone			£ per ha
		SFP	SBS	LFASS	1) Hill	2) In-bye	3) Low - arable	4) Low - HV arable
1) Woodland creation and management								
Woodland creation	100%	Unchanged	Reduced to zero	Reduced to zero	69	104	466	632
Agroforestry	50%	Unchanged	Reduced pro-rata	Unchanged	24	38		
2) Land management								
Land and soil management - e.g. reducing stocking density	50%	Unchanged	Reduced pro-rata	Unchanged	24	38		
Agricultural and upland drainage - e.g. blocking tile drains	50%	Unchanged	Reduced pro-rata	Unchanged	24	38		
3) Working within and on the banks of the channel								
Bank restoration - removing existing banks	Switch from crops to grass	Unchanged	Reduced pro-rata	Unchanged	24	38	326	474
Fencing off watercourse	100%	Reduced to zero	Reduced to zero	Reduced to zero	144	210	734	878
4) Runoff (pathway) management								
Creation of wetlands	100%	Reduced to zero	Reduced to zero	Reduced to zero	144	210	734	878
LOWER 25% farm performance	Assumed fall in ag. output	Eligibility for subsidy			Net Income Foregone			£ per ha
		Single Farm Payment	Headage payments	LFASS	1) Hill	2) In-bye	3) Low - arable	4) Low - HV arable
1) Woodland creation and management								
Woodland creation	100%	Unchanged	Reduced to zero	Reduced to zero	18	37	231	225
Agroforestry	50%	Unchanged	Reduced pro-rata	Unchanged	0	12		
2) Land management								
Land and soil management - e.g. reducing stocking density	50%	Unchanged	Reduced pro-rata	Unchanged	0	12		
Agricultural and upland drainage - e.g. blocking tile drains	50%	Unchanged	Reduced pro-rata	Unchanged	0	12		
3) Working within and on the banks of the channel								
Bank restoration - removing existing banks	Switch from crops to grass	Unchanged	Reduced pro-rata	Unchanged	0	12	296	393
Fencing off watercourse	100%	Reduced to zero	Reduced to zero	Reduced to zero	102	117	574	558
4) Runoff (pathway) management								
Creation of wetlands	100%	Reduced to zero	Reduced to zero	Reduced to zero	102	117	574	558

It should be noted that the assumptions made are general in nature and can only give a guide to the potential income foregone payments that might be justified for each category. More detailed prescriptions for each NFM measure will be needed to more clearly define the likely loss of agricultural output and the impact on subsidy payments.

These estimates do not include any payments for additional costs and management time that may be incurred. An indication of the potential additional costs by NFM measure is detailed in table 6. In practice, the extent of any additional costs will be site specific and may apply in some cases and not in others.

Table 6: Potential additional costs and benefits associated with creation of different NFM measures

	Potential additional direct costs	Potential additional management time	Potential additional risks	Potential benefits
Woodland creation	Rent additional grazing Transport stock	Travel and supervise rented grass		Shelter Separate stock for management and health
Agroforestry	Rent additional grazing Transport stock	Travel and supervise rented grass		Shelter
Reduced stocking	Rent additional grazing Transport stock	Travel and supervise rented grass		Reduced animal worm burden
Blocking drains	Rent additional grazing Transport stock	Travel and supervise rented grass	Higher risk of liver fluke	
Remove existing banks	Transport and temporary grazing or feed during flooding Loss of feed/ crop	Greater supervision of stock/crops during flooding	Damage to standing crops/stock Damage to fences	Reduced flood risk to other land
Fence off water courses	Rent additional grazing Transport stock	Travel and supervise rented grass		Separate stock for management and health
Creation of wetlands	Rent additional grazing Transport stock	Travel and supervise rented grass		Reduced flood risk to other land

3.2.3 Informing policy development

The results detailed above reveal a number of messages which will help inform the development of relevant policies, including:

- The impact of different NFM measures on agricultural land use and income will vary according to the type and mode of operation of the measures concerned and their physical location within the landscape and farming system
- Scottish Government's Farm Accounts Survey provides good, robust estimates of income foregone for different typical land classes, which can be further supported by inclusion of data from specific regions as relevant
- The main financial impacts to be covered should include loss of agricultural income; loss of agricultural subsidies; retention of other fixed costs and additional management costs, offset by reductions in variable costs and some fixed costs
- The impact on subsidy income can be assessed through consideration of impacts of NFM implementation on the main agricultural support schemes (SFP, SBS and LFASS)
- Results show that loss of income, and therefore level of income foregone is highest on the best performing land, such that the costs of compensation will be greatly reduced by targeting NFM measures on poorer lands and farms
- Subsidy payments play an important role in pushing up the cost of compensation. Removing land from eligibility for agricultural subsidies results in a marked rise in compensation required. The relative effect is much greater on poorer hill land where subsidies make up a higher proportion of farm income.

4.0 Assessing acceptability of potential compensation levels for implementing natural flood management measures

The third part of the work combines the results from parts one and two and solicits farmers' opinions and preferences as to the type of NFM measures that they would be willing to implement, given a range of financial compensation levels to address negatively impacted farm income. The resulting questionnaire could be considered a "reality test" as experienced farmers and land managers were the sample group questioned.

4.1 Detailed methodology

The survey was undertaken using Survey Monkey, an open source survey application; the main target for this questionnaire being respondents to the first survey. These farmers were emailed a report on the preliminary findings of the first survey, covering the relative acceptability or unacceptability of different NFM measures, and requested to take part in the follow-up survey.

The survey was designed to also be undertaken by others who had not participated in the initial survey so, in addition, invitations to participate were sent out through the same network of contacts as for the first survey across the Tweed catchment (Tweed Forum, NFU Scotland and Scottish Land and Estates). All persons contacted were provided with a web link to the survey online which was open during October and November 2014. Twenty five responses were received.

The questions were designed to explore two issues:

- 1) did the farm business model that we developed accurately determine the income foregone as a result of implementing NFM measures; and
- 2) the likelihood of farmers accepting the different levels of compensation identified for the specific NFM measures proposed on different land types.

The survey was not intended as a means to set compensation levels per se, rather to give information about how favourably farmers see potential levels in respect of particular NFM measures. We recognise that actual mechanisms for compensation, such as SRDP, each have their own requirements and rules that would need to be followed. The survey was based upon a matrix of NFM measures and land use types, from which participants were asked to state their likelihood of accepting three levels of financial compensation proposed. From the results of the earlier work, a selection of representative NFM measures were identified as being potentially acceptable to farmers across the four land use types for reducing flood risk (table 7).

The three compensation levels offered were based on the average value, as determined from the results of the income foregone calculations in the previous analysis, plus a higher and lower value that was rounded up to be approximately 30% higher or lower than the average. Four possible answers were available to the survey participants: "Not at all", "Possible", "Likely" and "Highly Likely". The "Not at all" answer is interpreted as a clear negative response. The "Possible" answer is interpreted as on the margin between a negative and positive response, and is considered to be unlikely to be accepted. The remaining two answers are interpreted as being positive.

Two additional questions were also presented in the survey. The opening question asked if the farmer believed the farm business model addressed the main issues in determining the average income generated by the four farm land types, the last asked for any further comments. All participants were also given the opportunity of asking for a copy of the final report.

Table 7: Land use types and NFM measures used in the survey

Land use type	NFM Measure
Hill – unimproved grassland	<ul style="list-style-type: none"> • Upland woodland planting • Blocking upland drains/moorland grips • Reducing stock numbers by 50%
In-bye – improved grassland	<ul style="list-style-type: none"> • In-bye woodland planting • Tree planting in gullies • Cross-slope woodland shelter belts • Reducing stock numbers by 50% • Fencing off water courses
Lowland – arable	<ul style="list-style-type: none"> • Fencing off water courses • Creating sacrificial wetland areas in strategic locations to capture overland flood flows and sediment • Removing flood banks and conversion to grass
Lowland – high value arable	<ul style="list-style-type: none"> • Fencing off water courses • Creating 'sacrificial wetland' areas in strategic locations to capture overland flood flows and sediment • Removing flood banks and conversion to grass

4.2 Farm Business Methodology

After reading a one page description of the methodology used to model finances of farm businesses in Scotland, respondents were asked, "Do you consider that the methodology used to determine income foregone covers the main issues?" 84% of respondents who answered this question (16/19) agreed, with 16% (3) answering in the negative.

All three negative respondents wrote an accompanying comment: two referred to the "effect on the whole business" and the "viability of the remaining holding not covered by NFM techniques", noting that it might impact on the "value of the holding both as a rentable unit and as a freehold unit" (though also noting that this "could be increased or decreased"); and the third to the "effect on land drainage", noting that "If land is to be flooded there are implications for the tile drainage systems which, until the land was flooded, drained into the flooded areas", but going on to acknowledge that "the problem can be obviated by redirecting the tile systems but there is a cost in so doing."

Notwithstanding these comments, we can conclude that the farm business model utilised is strongly perceived by farmers to cover the main issues in determining the average value of income foregone for implementing NFM measures for the four main types of Scottish farmland.

4.3 Results of assessing acceptability of compensation for implementing NFM measures

The survey posed a 14 'likelihood' questions to participants (4 land use types x 3-5 different NFM measures on each) and in nearly all instances these elicited a neutral or positive response ('possible' or better). Despite the repeated efforts to recruit farmers to the survey, actual numbers of respondents were disappointingly low, with only 25 returning the survey. Caution must therefore be taken with the small sample size. However, the business model approach utilised was demonstrated to be accurate, as the different compensation levels used in the questions (as derived from the income foregone analyses) were sufficient to promote a 'likely' or 'highly likely' response from farmers, though notwithstanding the potential that overcompensation might be possible.

Full details of the responses to each question on compensation levels for the different NFM methods on each of the four land uses are available. Here, we summarise the key findings.

4.3.1 Hill – unimproved grassland

Three NFM measures identified as being potentially acceptable to farmers on upland hill farms were examined.

1 Upland Woodland Planting

Responses indicate that the estimated values accurately reflect the compensation necessary to motivate some farmers to implement upland woodland planting. The responses meet with standard economic theory, in that whereas at the lowest level no respondents were 'Likely' or 'Highly Likely' to participate, as the incentive increased in value they become more willing to plant upland woodlands. At the highest level, almost 50% (of the 13 respondents to this section) were 'Likely' or 'Highly Likely' to consider this NFM measure. It is interesting to note however that even at this level, some respondents were 'not at

all' likely to participate in such a scheme, suggesting that money will not always be the determining factor.

In summary, we see that incentives at the average level of £69/ha/yr. or higher would be sufficient to motivate some farmers to implement upland wood planting as a NFM measure, increasing as the compensation rises.

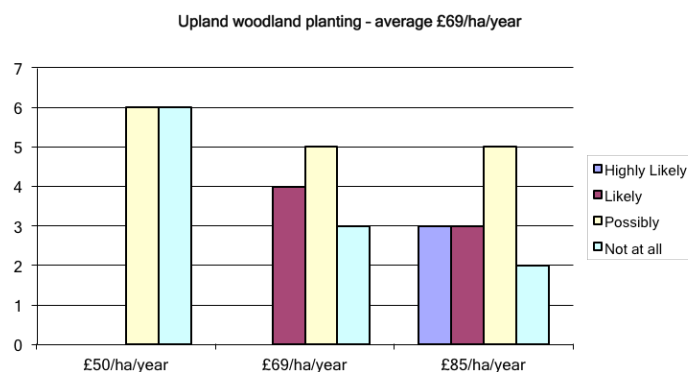


Figure 2 Number of farmers likely to accept different levels of compensation for upland woodland planting

2 Blocking upland drains/moorland grips

There is little support for this NFM measure at the proposed incentive levels and over 85% of respondents state "Possibly" or "Not at all" for all levels of compensation offered. As the incentive increases there is a shift from "Not at all" to "Possibly" but no increase in the "Likely" or "Highly likely" categories. This may indicate that whilst farmers are considering the incentive, the monetary value is not sufficient to receive a "Likely" or "Highly likely" response. Fourteen of 25 respondents answered this question for one or more compensation levels. Of note, one respondent was "Highly likely" to accept the incentive at all levels of incentive, perhaps suggesting that specific individuals may be willing to implement drain blocking given specific farm or farmer characteristics, irrespective to some extent of the level of payment on offer.

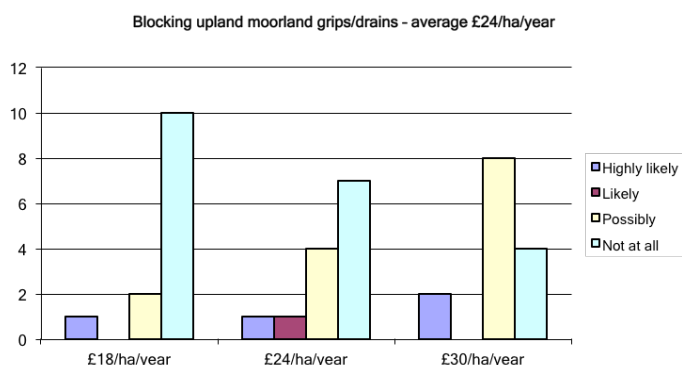


Figure 3 Number of farmers likely to accept different levels of compensation for blocking upland moorland grips/drains

Even incentives at £30/ha/yr. are insufficient to motivate most farmers to implement drain blocking as a NFM measure. This is perhaps not surprising as there could be a perception that such a widespread activity could take out large areas of land with relatively low levels of compensation. Either a higher level of compensation would be necessary to initiate change or, more likely acceptability will depend on individual circumstances.

3 Reducing stock numbers by 50%

There is very little support for this NFM measure at the proposed incentive levels. It should be noted that a 50% level

of stock reduction is in itself a very high figure, but was set to indicate a level that would make a measurable impact through reducing soil compaction and surface water runoff. All 13 respondents for this option stated “Possibly” or “Not at all” for all levels of compensation offered. Even though the “Possible” category does increase as the incentive increases, indicating that farmers are at least responding to the incentive, reducing stock numbers on hill farms remains one of the least attractive of the NFM measures proposed.

4.3.2 In-bye – improved grassland

Five NFM measures were identified as being potentially acceptable to farmers on in-bye land.

1 In-bye Woodland Planting

Responses indicate that the estimated values accurately reflect the compensation necessary to motivate some farmers to implement in-bye woodland planting. At the highest value, almost half of the respondents (6/13 for this option) are either “Likely” or “Highly Likely” to participate in this measure.

Incentives at £80/ha/yr. or higher are seen as being sufficient to motivate some farmers to implement in-bye wood planting. As the incentive increases, more farmers are likely to implement this measure.

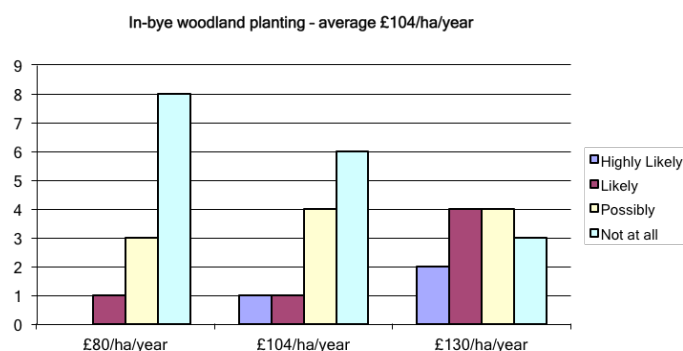


Figure 4 Number of farmers likely to accept different levels of compensation for in-bye woodland planting

2 Tree planting in Gullies

Responses indicate that the estimated values accurately reflect the compensation necessary to motivate some farmers to implement in-bye woodland planting in gullies. Whilst many would not consider it at the lowest level of compensation, at the highest compensation level, all respondents (13) indicated they were “Possibly”, “Likely” or “Highly likely” to consider this measure, whereas at the lowest level only four were, and eight would not consider it at all.

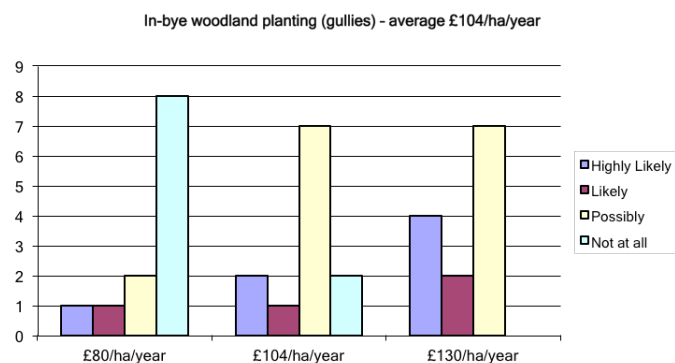


Figure 5 Number of farmers likely to accept different levels of compensation for in-bye woodland planting in gullies

As the incentive increases, significantly more farmers indicate an increasing likelihood of implementing this measure, with apparently a greater willingness at the higher compensation level than for woodland planting elsewhere on in-bye land at the same level.

3 Cross slope woodland shelter belts

Responses indicate that the estimated values accurately reflect the compensation necessary to motivate some farmers to implement cross slope woodland shelter belts as an NFM measure. At the highest compensation level, 11 (of 13) respondents indicate they are “Possibly”, “Likely” or “Highly likely” to consider this measure.

Incentives at £80/ha/yr. or higher are sufficient to motivate some farmers to consider implementing cross slope woodland shelter belts as a NFM measure, but many would not. However, as the incentive increases significantly more farmers indicate an increasing likelihood of implementation.

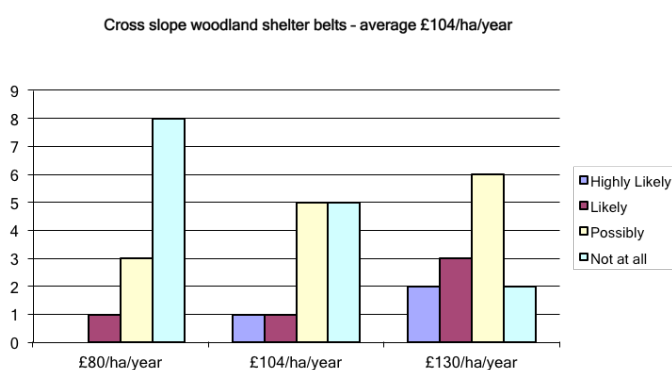


Figure 6 Number of farmers likely to accept different levels of compensation for cross slope woodland planting

4 Reducing stock numbers by 50%

There is little support for this NFM measure at the lower proposed incentive levels, and even at the highest compensation level only three of 13 respondents indicate they are “Likely” to consider this. Unlike other responses, there appears to be some inconsistency, partly reflecting the variable number of respondents to each incentive level. The results from this question should be considered with caution as a result.

5 Fencing off watercourses

Responses indicate that the average value and, in particular the higher value reflects the compensation necessary to motivate some farmers to fence off watercourses as an NFM measure.

Whatever the apparent potential inconsistencies in some areas of this response, it is clear that at incentive levels of £210/ha/yr., farmers will at least consider this option. At the enhanced level of £265/ha/yr. nearly 70% of farmers give a “Likely” or “Highly likely” response to fencing off watercourses, making it an attractive proposition to many.

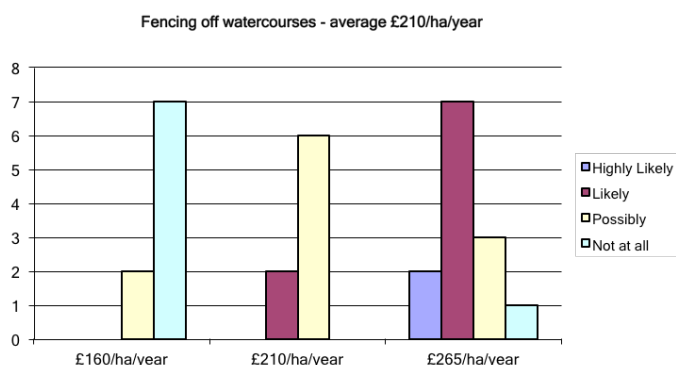


Figure 7 Number of farmers likely to accept different levels of compensation for fencing off water courses

4.3.3 Lowland – arable

Three NFM measures were identified as being potentially acceptable to farmers on lowland arable land.

1 Fencing off land adjacent to water courses

At the highest compensation level of £920/ha/yr. three of the seven respondents indicated a “Highly likely” response to fencing off watercourses as a NFM measure. At the lowest incentive level (£550/ha/yr.) all respondents indicated either a “Not at all” or just a “Possible” response, perhaps reflecting the high value of potential loss of arable land such a measure would entail. The average figure in between these values attracted a mixed response, with three of the eight respondents in this category indicating ‘Likely’ or ‘Possible’, but the other five ‘Not at all’.

This is highly valuable agricultural land and any introduction of NFM measures on a large scale would seem unlikely and unwarranted from both the perspective of agricultural production and food security. At an incentive level equal to £734/ha/yr. or above, some farmers are “Likely” or “Highly likely” to participate in fencing off watercourses. Such an activity could potentially deliver NFM benefits but occupy only a small area of productive land.

2 Creating areas of ‘sacrificial’ wetlands

On arable land, there is little support at the proposed incentive levels for setting aside areas of land that would be allowed to flood temporarily. Five of seven respondents would not consider it at all at the average figure of £734/ha/yr. Even at the highest compensation level of £810/ha/yr., only two of the eight respondents in this category gave a “Likely” or “Highly likely” response. One respondent was “Highly likely” to accept at the highest levels of incentive. This may indicate some farmers may be in unique or uncommon circumstances that allow them to consider this option. Clearly, the exact location and deployment of such wetland areas across a catchment landscape would need careful planning to be effective, so this NFM measure

should not be entirely ruled out, with each catchment and farm circumstance being assessed on its own merits and recognising the other potential benefits such as preventing soil erosion.

3 Removing flood banks and switching to grass

There is no support for the removal of flood banks and switching to grassland at the lowest incentive value of £245/ha/yr. Removal of flood banks would increase the likelihood of river flooding at times of high flow and require the farmer to switch the impacted areas to grass production, rather than stay in arable. At the average figure of £326/ha/yr., one of two farmers indicated “Likely” acceptance of the average incentive value. At the highest value of £410/ha/yr. two of the eight respondents would be “Highly likely” to consider this NFM measure. Only eight of the 25 survey respondents answered this specific question at one or more compensation levels, which creates some uncertainty as to any further interpretation.

4.3.4 Lowland – high value arable

Three NFM measures were identified as being potentially acceptable to farmers on high value arable land. Very few responses were received from participants for this land use, probably reflecting its high value as productive farmland and historic investment in protecting it from flooding.

1 Fencing off water courses

There is very little support for fencing off land adjacent to watercourses as an NFM measure in areas of high value arable land. No respondents showed interest at £660/ha/yr. (lower level) and at the average incentive level (£878/ha/yr.) only one of four indicated “Possibly” accepting the compensation. Even at the highest level (£1,100/ha/yr.), only one of three respondents stated they would be “Likely” to consider fencing off land adjacent to a watercourse. Given the small number of responses, the results should be considered indicative and not robust. Whilst the upper end of the range appears to be approaching a level that might incentivise farmers to consider this NFM measure, at this value it would be an expensive option.

2 Creating areas of ‘sacrificial’ wetland

None of the levels of incentive proposed in this option were sufficient to motivate farmers to consider this as either “Likely” or “Highly Likely”. The responses did shift from a mix of “Not at all” or “Possibly” at the lower and average incentive levels (£660/ha/yr. and 878/ha/yr.), to all responses being “Possibly” at the highest value (£1,100/ha/yr.). Given the small response size, the results should be considered indicative and not robust. However, the values being used are likely to be at the lower end of a range that might incentivise farmers to consider this NFM measure in areas of high value arable lowland.

3 Removing flood banks and switch to grass

There is no support for the removal of flood banks and switching to grassland at the lowest (£355/ha/yr.) or average (£474/ha/yr.) incentive levels. No farmers indicated they were either “Likely” or “Highly Likely” to consider this NFM measure within this compensation range. At the highest value (£595/ha/yr.), two additional respondents indicated they would “Possibly” consider this change of land use for flood management. Higher values would be required to increase the likelihood of attracting farmers to this NFM measure, were it considered appropriate so to do.

4.3.5 Additional comments from respondents

Participants in the survey were also invited to add any additional comments, anonymously if wanted; six provided comments. One made the very valid point that the survey approach assumes that the NFM methods proposed all actually work: “we have never been asked if we think this will be useful in preventing flooding”, going on to add that if the effects of these NFM measures “is to be properly assessed the extra quantity of water stored has to be measured, and this is never done”.

Whether the proposals would work or not, another respondent indicated that there were some “absolutely ridiculous suggestions put forward for agricultural land, as it would make so much of it worthless for anything”. However, an alternate view presented was that “while the financial incentive is important, the main decision-making comes when the actual location is suggested.” This was echoed by others, who made the point that “some sites are more suitable than others” and that “a blanket approach is not necessarily the answer”, with another respondent noting that “amenity value of tree planting would benefit diversification into tourism”. The report, by design focusses on compensation whereas, as this respondent mentions, some NFM measures may be directly beneficial to farm operations (e.g. in reducing soil erosion and loss of top soil).

A final comment on the process was that “any works should be done in conjunction with the Scottish Government’s Rural Payments and Inspections Directorate so that they approve the plans, etc. and advise claimants how to keep themselves right with future subsidy claims”.

4.4 Assessing the acceptability of potential compensation levels for implementing NFM measures – Summary:

The methodology used in this study is strongly perceived by farmers responding to the survey as covering the main issues when estimating the foregone revenue that would result from implementing NFM measures. This finding is supported by both the explicit agreement of the respondents and the majority of answers to the questions in the survey. The business model is demonstrated to be accurate when compensation levels derived from the business model and used in the questions are seen as sufficient to promote a “Likely” or “Highly Likely” response from farmers.

Key messages that help inform policy development include:

- The methodology used to assess the impact of NFM measures on farm businesses is robust and fit for purpose
- In all 14 situations where an NFM measure was proposed on one of the four farm types, the compensation levels offered produced at least a neutral (possible) and in most cases a positive (likely or highly likely) response from respondents
- In most cases, and in line with economic theory, increasing the level of compensation led to an increase in the likelihood of that measure being seen as acceptable for that specific land use type
- The NFM measures that were perceived as being most acceptable to be taken up at the compensation levels proposed were:

Hill – unimproved grassland:

- Upland woodland planting

In-bye – improved grassland:

- In-bye woodland planting
- In-bye Gully woodlands
- Cross-slope shelter belts
- Fencing off water courses

Lowland – arable

- Fencing off water courses

- The NFM measures that were perceived as being least acceptable to be taken up at the compensation levels proposed were:

Hill – unimproved grassland:

- Reducing stock numbers by 50%

In-bye – improved grassland:

- Reducing stock numbers by 50%

Lowland – arable

- Creating areas of sacrificial wetlands to capture overland flows and sediment

Lowland – high value arable

- Creating areas of sacrificial wetlands to capture overland flows and sediment
- Removing flood banks and switching to grass

- Three options for NFM measures proposed produced inconsistent responses, or were only answered by a small number of responders. However, in some instances it appears that individual circumstances might make these attractive (indeed this was even a possibility in those situations above where the option was seen as being least acceptable):

Hill – unimproved grassland:

- Blocking upland drains/moorland grips

Lowland – arable

- Removing flood banks and switching to grass.

Lowland – high value arable

- Fencing off water courses

5.0 Discussion: informing the design of mechanisms to target implementation of natural flood management measures

This analysis comes at an important time when there is growing interest in the use of NFM techniques as a core element of sustainable flood risk management strategies. In Scotland, NFM is seen not only as fundamental to the aims and delivery of the Flood Risk Management (Scotland) Act 2009 (Spray *et al* 2010), but also as part of a wider overall approach to the delivery of multiple benefits and ecosystem services from integrated land management. This has been taken forward by the Scottish Government in its Land Use Strategy (www.scotland.gov.uk/landusestrategy), in which they set out a vision to guide thinking about the way we use our land and how we want to see that develop in the future. Flood risk management, the significance of which has been raised through concerns surrounding climate change, food and energy security, is central to this debate and NFM is central to the development of potential policy solutions for our rural and agricultural landscapes and businesses.

The potential use of NFM techniques has attracted the attention of policy-makers, academics and practitioners (Kenyon & Langan 2011; POSTnote 2011; Rouillard *et al* 2014; 2012). Actual implementation and uptake though has been hampered by a number of factors including: perceptions and uncertainties around the effectiveness of widespread adoption of certain NFM measures in terms of their sustained ability to reduce flood risk at a catchment scale (O'Connell *et al* 2007; Parrot *et al* 2009); barriers created by uncertainties in funding mechanisms and policies to support behavioural change (Holstead *et al* 2012); and a lack of knowledge of their social and economic impacts on farm businesses (Beedell *et al* 2012).

The effectiveness of NFM measures will depend on their position within the catchment, in particular whether they are situated in the upper/middle/lowland part of a catchment and whether they are located on the hills or in the floodplain (O'Connell *et al* 2004; Frances *et al* 2008). Our approach has been to analyse NFM measures in the context of within which farming systems and location they are most likely to be positioned (aligned also to the SEPA NFM Handbook), but not to try to assess their effectiveness in reducing flood risk, nor their hydrological impact either as individual installations or in combination with other NFM initiatives within a wider catchment approach.

The potential impact of NFM measures on farm income foregone will similarly reflect their location within the farming system. Whilst it is recognised that some farms will be located across more than one type of land class/use, we have based our analysis on the main farm typologies used by the Scottish Government's Agriculture, Food and Rural Communities Directorate for calculating farm business income, and, in addition utilised information derived directly from the Scottish Government's own Farm Accounts Survey. In doing so, we hope our methodology and outputs align with those used in policy development and support.

There is ample literature investigating what influences the decision-making of farmers, so as to realise the opportunities for securing changes in land management (Kenyon & Langan

2011; Hallam 2011). Many social and psychological factors will also influence farmers' decision-making (Bullock 2011). Holstead *et al* (2012) list nine groups of factors that influence land manager decision-making on NFM and, whilst this project has not attempted to cover all of these, our approach has recognised their importance, including factors such as farm characteristics and support mechanisms, while focussing on attitudes and economic impacts of potential land management for increased flood resilience.

5.1 Potential policy instruments to support implementation of Natural Flood Management

Policy instruments are typically divided into those of a regulatory nature, an economic nature or those that operate through information provision. There is a growing body of information which tries to identify the types of policy instruments most likely to help secure the uptake of NFM (see for example, Rouillard 2012; Kenyon & Langan 2011; Beedell *et al* 2012). Various regulatory and information provisions which favour adoption of NFM already exist within the EC Water Framework Directive and Floods Directive. Changes in land management may also be encouraged via economic and financial incentives (Beedell *et al* 2012) and a number of potential mechanisms exist for compensating land managers (RPA, RHDHV and Allathan Associates (2015)).

Within Scotland, the policy context offers in particular two potential approaches for encouraging NFM via economic incentives:

- Exploring the possibility of introducing new mechanisms within existing legislation, including via the Flood Risk Management (Scotland) Act 2009 provision allowing agreements to be established between local authorities and land managers; and
- Using the existing Scottish Rural Development Programme, in particular Rural Priorities under which capital grants and annual payments can be provided to land managers, to make it better able to accommodate NFM and improving payment rates to take account of the service provided.

5.1.1 Existing policy provisions, including Flood Risk Management (Scotland) Act 2009

The opportunity to introduce new mechanisms through the use of current policy provisions including, but not limited to, flood legislation has recently been explored by the Scottish Government (see: RPA, RHDHV and Allathan Associates (2015) 'Assessing the mechanisms for compensating land managers'). Beedell *et al* (2012) also examined the range of policy instruments that might be used to encourage land managers to provide NFM services. They concluded that a range of approaches could be utilised, including not solely economic instruments and regulatory measures, but also voluntary means, advice and technical support.

The outputs from our current research support and extend the conclusions of this earlier work. In particular the results from the farmer surveys show:

- **Purchase of land:** Very little support is shown for outright purchase of land for NFM. Whilst our results show a similar unfavourable response to 'sale and lease back', this is recognised by Beedell *et al* (2012) as being more attractive

in some circumstances, but more complex to arrange.

- **Easements on potential NFM sites:** These have been extensively used by the Environment Agency (as the flood authority in England and Wales), and in limited situations in Scotland. Our research clearly shows that the loss of control over how land may be used in the future was a noticeable concern from respondents. However, the question of easements per se was not something we examined, rather the nature of payments for the delivery of different flood reduction 'services' through NFM implementation.
- **Tax-based incentives:** Economic instruments, including tax initiatives have been used elsewhere and we asked participants for their responses to these and a range of other potential incentives. The response was rather polarised, and may reflect lack of clarity with the nature of incentive, though just over half indicated a very favourable response. This could be something therefore for further investigation, linked to defined outputs from land management activities covered.
- **Auction schemes and service trading options:** Our responses indicate that at present they might not be considered so favourably. However, there was a spread of responses to these questions, with a few respondents indicating they would definitely consider. As noted by Beedell et al (2012), there may therefore be scope for creating markets in 'flood reduction services'.
- **Voluntary and non-financial incentives:** Whilst not part of the mechanisms explored by the earlier study, and not considered as good an incentive as annual payments, our results suggest that receiving a favourable weighting for environmental grants was considered a good incentive. However, financial incentives were clearly favoured over non-financial ones.

5.1.2 The Scottish Rural Development Programme

The Scottish Rural Development Programme (SRDP) 2014 - 2020 delivers Pillar 2 of the EU Common Agricultural Policy through funding economic, environmental and social measures for the benefit of rural Scotland (see: <http://www.scotland.gov.uk/Topics/farmingrural/SRDP>). The SRDP is co-funded by the European Commission and the Scottish Government and reflects both the six EU Rural Development Priorities and the Scottish Government's own National Performance Framework.

Details of the SRDP 2014 – 2020 include several for which NFM developments can be seen as potentially highly relevant elements. These include:

- **Rural Development: LFASS** - support to fragile farming businesses in remote and constrained rural areas (*which would include many within areas identified as being target areas for NFM*)
- **Rural Development: Forestry Grant Scheme** - includes woodland creation and improvement, agroforestry and sustainable management of forests (*woodland planting is a key element of NFM*)
- **Rural Development: Agri-Environment Climate Scheme** - targeted support for land managers to undertake management and capital work for environmental purposes (*much of NFM can be seen as improving the resilience of rural businesses to climate change*)
- **Rural Development: Environmental Co-operation Action Fund** - facilitation for land managers to work together to deliver collaborative environmental projects (*for NFM to*

'work' at a catchment scale, collaborative projects between neighbouring land owners will be vital)

- **Rural Development: Knowledge Transfer and Innovation Fund** –ensuring that learning from research is transferred to working practices and on the ground improvement (*we identify a role for knowledge transfer in encouraging the uptake of NFM*)
- **Rural Development: Advisory Service** – development of an expanded Advisory Service to provide advice and assistance to farmers, crofters, forest holders and other land managers (*we see providing advice and support as a key part of the dissemination and successful uptake of NFM*)
- **Scottish Rural Network** - supporting and promoting rural development through sharing ideas and best practice (*there is clearly a role for NFM to be included in this*).

Returns from our surveys would support the earlier conclusions from Beedell et al (2012) in that farmers were most happy if they were offered annual payments in return for services delivered through their ongoing farm practices and procedures, such as SRDP. There was considerable interest expressed in responses to our question about annual payments for enhancing the environment. Comments from the 'free section' of the survey however very much showed the antagonism towards the administrative burden and complications of engaging with agricultural support mechanisms and, indeed towards some of the organisations involved with its delivery and administration.

The surveys also show the importance of having evidence of the effectiveness of NFM measures, and to a lesser extent, seeing it in action, before farmers would commit to a scheme. This, along with the emphasis on face-to-face communication on the farm and on knowing who to contact if there were problems with NFM measures all support the importance of the SRDP Rural Development: Knowledge Transfer and Innovation Fund; the SRDP Advisory Service and the Scottish Rural Network as being key means for encouraging NFM dissemination and uptake. There is clearly a role for an enhanced and integrated advisory service with respondents indicating that Scottish Government, SEPA, NFU Scotland and farm advisers were all seen as important, and they along with local authorities and NGO land management organisations should have a key role in NFM support and promotion.

There remains various challenges and constraints to implementation of NFM through SRDP, the first two of which could be major constraints to its implementation and effectiveness:

Time - To be effective, NFM measures must be established and then operated for the long-term. There are huge risks for any policy approach that takes a long-term sustainable view, but is then constrained by the short-term nature of funding support mechanisms. Any agreement to support NFM measures must have a longer funding commitment (from both government and land managers) than is usual for many SRPD options. This relates both to the continuing operation of NFM measures and the fact that some measures (e.g. woodland planting) will take time to become effective as they mature.

Collaborative catchment action – flooding is not constrained by property boundaries or management units. NFM measures need to be 'joined up' across the catchment landscape - in space, in time and in the targets of their purpose. Having a competitive bidding process for allocation of NFM grants would

be counter-productive. Collaborative applications by farmers within a sub-catchment are both desirable and necessary for NFM to work. This can be influenced by regional prioritisation of NFM areas and schemes, but effective deployment of NFM will also need the means through which adjacent land managers can be encouraged to cooperate at a catchment scale.

Scale – Individual NFM components need to be as large as possible and, where possible linked to others. There is still uncertainty as to the effectiveness of individual measures isolated in the landscape adding up to produce a catchment-scale response to flood risks.

Measurement of effectiveness of benefits – whatever the mechanism for policy intervention, there is the need to determine the measure of effectiveness – both in terms of designing the scheme so that all participants are clear what they are being paid to deliver (outputs, such as watercourses fenced off, or outcomes, such as reduced frequency of flooding), and in terms of physical measurement of the effectiveness of NFM measures in reducing flood risk. Having ‘proof’ of effectiveness was a key point raised in responses to the surveys.

5.2 Targeting NFM measures on Scottish farms

Our research shows that certain NFM measures are more attractive to farmers than others, notwithstanding any differences in their physical effectiveness of reducing flood risk or the support mechanisms through which they might be introduced and maintained. It is also clear that their acceptability is different between different farm types, and this also needs to be considered when assessing the priorities for support for their introduction in different farming systems.

We suggest that NFM policy is directed towards the following measures and locations. We also stress that in doing so, acknowledgement should be made of the many other benefits such NFM schemes will deliver, such as biodiversity (native woodlands), water quality (cross-slope shelter belts reducing sediment and nutrient run-off), better stock management and disease control (fencing off watercourses), carbon management (woodland expansion) and landscape and recreation (including fishery enhancements and walking). This raises the question and possibility that the costs of income foregone, and the potential mechanisms for farmer compensation in these instances could be assessed against the co-delivery of a number of other ‘public goods’ – the multiple benefits or ecosystem services described above.

A key recommendation is that policy and practice must both take a catchment approach to the planning, approval, design and implementation of NFM measures across the landscape. The exact locations of the individual elements need to be agreed on site once a farm and sub-catchment assessment has been made - e.g. the precise location of woodland blocks, the positioning of cross-slope shelter belts, etc. – and all farmers and land managers within the catchment involved in creating and taking forward the desired programme.

5.2.1 Primary NFM Measures:

In setting out any list of measures for NFM delivery, it should be recognised that NFM measures will deliver for flood risk reduction at different scales and that some will be more effective than others. Those that are not favoured by farmers

may still be relevant and the introduction of less favoured but more effective measures may require other incentives and means by which they can be promoted. The measures proposed (see section 4.4) are those that are deemed most favourable in respect of the views of land managers and the scope of the study undertaken.

(a) Woodland Planting

- *Hill – unimproved grassland:*
Upland native woodland planting at a large scale
- *In-bye – improved grassland:*
Native woodland planting in strategic locations
Gully woodlands
Cross-slope shelter belts

(b) Fencing off water courses:

- *In-bye – improved grassland*
- *Lowland – arable*

Fencing off watercourses could be combined with other actions within the newly fenced off areas that would increase biodiversity and enhance fisheries, as well improving nutrient control. It would also be very good if targeted as part of measures to improve ecological status of failing water bodies under the WFD, with work to help re-meander straightened rivers and enhance bankside planting. We also note that fencing off watercourses received a limited potential approval for Lowland – high value arable, but this would be very expensive. However, in certain circumstances, it should be explored on a site-by-site basis within the wider context of a particular sub-catchment with sustained flooding issues.

(a) and (b) can be seen as wide-spread general priorities, but there are other possibilities that should not be ruled out, including:

5.2.2 Secondary NFM Measures

(c) Blocking upland drains/moorland grips

- *Hill – unimproved grassland* – this received both enthusiastic support and strong opposition suggesting, perhaps that individual circumstances might make this an attractive option in some locations. It would also lead to enhanced carbon storage and potential improvements to water quality run-off, so its spatial prioritisation, promotion and funding support could be framed within that wider context.

(d) Removing flood banks and switching to grass

- *Lowland arable* – This option received a somewhat varied response, but it may be one that is worth discussion on a farm by farm basis within arable areas of floodplains regularly inundated with flood waters as an option, though recognising that it is a potentially expensive option.

(e) Creating areas of ‘sacrificial’ wetlands to capture overland flows and sediment

- *Lowland arable* – Whilst the exact location and deployment of ‘sacrificial’ wetland areas across a catchment landscape would need careful planning to be effective, this NFM measure should perhaps not be entirely ruled out, with each catchment and farm circumstance being assessed on its own merits, and recognising the potential extra benefits, such as reducing soil erosion that such wetland areas may deliver.

5.2.3 Other NFM Measures

Certain NFM measures were considered unacceptable at all the compensation levels proposed and unless they were to form part of another programme and rationale for farm diversification and funding, are not recommended. These include:

(f) Reducing stock numbers by 50%

- in neither Hill – *unimproved grassland* nor in *In-bye* – *improved grassland*

(g) Creating areas of sacrificial wetlands to capture overland flows and sediment

- *Lowland high value arable* – This would be very expensive and remove prime agricultural land from arable cultivation. Within a wider catchment approach however, it might be feasible to identify small, critical areas where this NFM measure would make a significant contribution to flood risk reduction. Therefore this NFM measure should not be entirely ruled out, with each catchment and farm circumstance being assessed on its own merits.

(h) Removing flood banks and switching to grass

- *Lowland – high value arable* – As noted above, this option would be very expensive and remove prime agricultural land from arable production. It was seen as unacceptable by most respondents, but it may be worth review on a farm by farm basis within floodplains regularly inundated with flood waters as an option, though recognising that it is expensive and, to be effective operationally would need integrating with the land use of neighbouring and adjacent farms.

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7.0 Abbreviations and Glossary

Abbreviations

- FAS - Farm Account Scheme
- FBI - Farm Business Income
- JHI – James Hutton Institute
- LFA – Less Favoured Area
- LFASS - Less Favoured Area Support Scheme
- NFM – Natural Flood Management
- NFU(S) – National Farmers Union (Scotland)
- SAC – Scottish Agricultural College
- SBC – Scottish Borders Council
- SBS - Scottish Beef Scheme (coupled head-age payment)
- SEPA – Scottish Environment Protection Agency
- SFP - Single Farm Payment
- SLE – Scottish Land and Estates
- SNH – Scottish Natural Heritage
- SRDP – Scottish Rural Development Programme
- SRUC – Scotland's Rural College
- WFD – Water Framework Directive

Glossary – use of terms in this project

Arable land - land which is or was in an arable crop (or under set aside or lying fallow as part of normal crop rotation) in one or more years during the last five. Lowland arable is characterised by cereal farms. Lowland arable high value by general cropping.

Floodplain - A floodplain is the area of land adjacent to a river made up of fluvial sediments which stretches from the channel to the edge of the valley sides, and which naturally experiences flooding during periods of high discharge. It includes the stream channel and adjacent areas that actively carry flood flows downstream. The building of levees, flood banks and other flood defences prevents high flows from spilling out of bank on to agricultural land or urban areas, but it also directs high flows downstream and cuts the river off from its floodplain.

Flood risk - The risk of flooding arises as a result of both a flood event itself and the vulnerability of the community, property or environment exposed to that event. It is thus a measure of the combination of the potential of harm from flooding (hazard), the exposure of life and property to flooding (exposure) and the vulnerability of communities and property to damage (vulnerability), which will include associated impacts on people, the economy and the environment.

Hill land - unimproved grassland, characterised by being within the Less Favoured Areas and specialist sheep farms.

Improved grassland - land used for grazing where over one third of the sward comprises, singly or in mixture, ryegrass, cocksfoot or timothy, or land that has been improved by management practices such as liming and top dressing.

In-bye land - land bounded by a fence or wall close to the farm which is used mainly for arable and grassland production, but which is not hill and rough grazings. It is usually improved grassland and characterised by specialist beef farms. It includes uncultivated field corners and field margins (such as water margins and hedgerows).

Income foregone - the estimated net loss of agricultural income to the farm business caused by the introduction and

maintenance of a natural flood management measure. It comprises both negative financial impacts (loss of agricultural income, loss of subsidies, retention of fixed costs of machinery) and positive ones (reduction in costs of fertiliser, feed, fuel). A key component is the impact on subsidy income through the respective loss (partial or complete) or retainment of income from the four main agricultural support schemes (Single Farm Payment, Basic Payments Scheme, Coupled Payments or Less Favoured Area Support Scheme).

Land manager - An individual or group that manages or controls the use and development of land. Many land-managers are farmers but other groups of particular relevance to natural flood management in Scotland include foresters and estate managers.

Land type - four main types of agricultural land use were identified for this project. These were based on matching land class (Hill, In-bye, Lowland) with typical farming types as used for data collection under the Scottish Government Farm Account Scheme.

Natural Flood Management - An approach to sustainable flood risk management which involves using the 'natural characteristics' of the catchment to intercept, slow down and temporarily store precipitation and flood waters. Natural flood management can operate across the whole catchment, including the sources of flood generation in the uplands, the pathways for flow along stream valleys and overland, and on to the valley floodplains. It does not replace traditional 'hard' flood defences, such as flood walls, but acts in a complementary manner to help reduce flood risk.

Natural Flood Management measure - a specific technique or type of land management practice that is designed to reduce flood risk. Such interventions are designed to utilise the natural characteristics of the landscape and enhance their potential to operate as 'soft' engineering options. NFM measures do not involve hard engineering structures (e.g. building a flood wall), but instead cover the introduction and maintenance of natural features such as woodlands and wetlands, and changes to tillage practices and stocking densities to slow down flows and act as temporary storage areas to hold flood waters. Full details are given in the SEPA Natural Flood Management Handbook.

Rough grazing - land, predominately in the uplands which contains semi natural vegetation including heathland, heather moorland, bog and rough grassland used or suitable for use as grazing.

Unimproved grassland - land used for grazing or mowing which is not normally treated with mineral fertiliser or lime and does not constitute either improved grassland or rough grazing.



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